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ENERGY CONSERVATION MANUAL

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FOR STATE OWNED AND STATE LEASED BUILDINGS

JANUARY 1979

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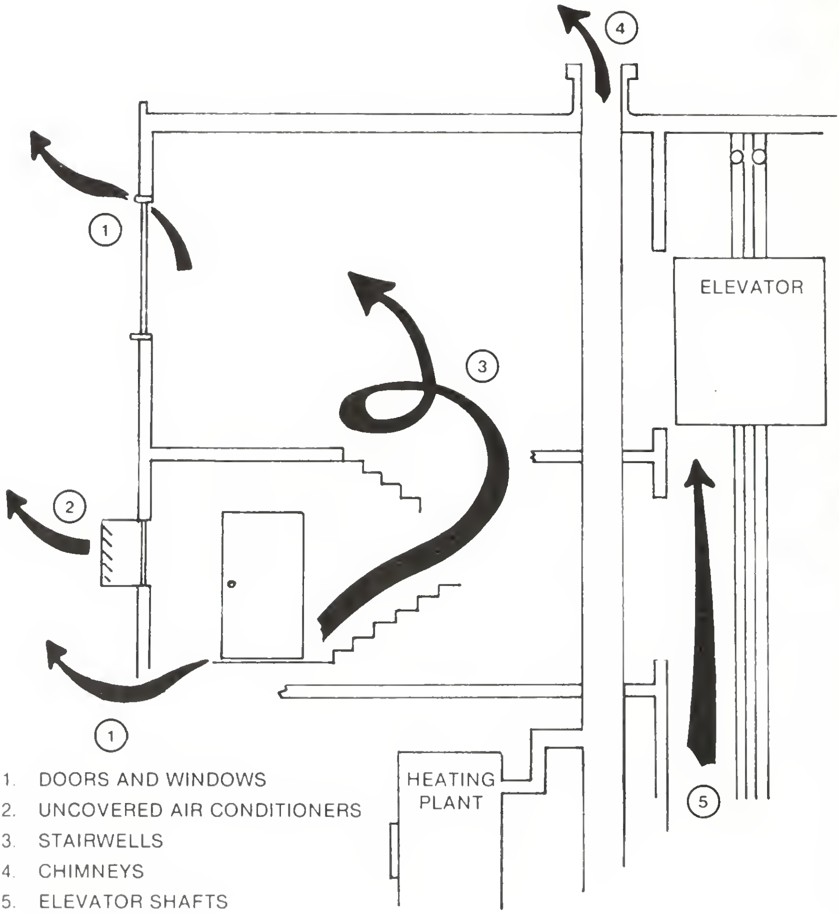

1. DOORS AND WINDOWS
2. UNCOVERED AIR CONDITIONERS
3. STAIRWELLS
4. CHIMNEYS
5. ELEVATOR SHAFTS

Major heat loss can take place in a well-insulated building through the openings shown. Much of that loss can be reduced or prevented by following the procedures outlined in this manual.

ENERGY CONSERVATION MANUAL

FOR STATE OWNED AND STATE LEASED BUILDINGS

BY
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MONTANA DEPARTMENT OF
NATURAL RESOURCES AND CONSERVATION
32 SOUTH EWING
HELENA, MONTANA 59601

JANUARY 1979

INTRODUCTION

OPERATION AND MAINTENANCE RECOMMENDATIONS

This operation and maintenance guide is intended as a practical manual for the building superintendants and heating engineers working in over 3100 buildings owned or leased by the State of Montana. Efficient fuel-conservative operation of heating and cooling systems is essential to consistent savings of both energy and money. The difference in operating and maintenance costs obtained by using these methods can be as much as 10 percent, a sizable reduction in overall expenses.

Most conservation procedures must be the responsibility of the engineer in charge of the building. The Operating and Maintenance (O & M) practices suggested in this manual will result in energy savings without significant increases in O & M expenditures or capital investments. The potential for applying each of the listed practices should be discussed by the building operator and the owner or manager, and appropriate action taken.

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SOURCES

Sources for the information in this manual include: U.S. Department of Energy, Montana Department of Administration guidelines, the Montana Energy Conservation Plan, and operation and maintenance guidelines developed for thirty-eight other states.

1. OPERATING AND MAINTENANCE SCHEDULING

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1.1 OPERATING RECORDS

A record of the schedule of operation and of the energy required by the building should be kept for each month. Such a record will be a valuable indicator of the impacts of any conservation measure taken.

1.2 MAINTENANCE SCHEDULE

A specific maintenance schedule should be established and diligently followed to ensure that all components of the building are maintained to operate at maximum efficiency. These recommendations may serve as helpful guidance in developing an O & M schedule. No general list can be entirely applicable or all inclusive for every building. Each building is unique in its optimum O & M scheduling and application.

Manufacturers literature should be consulted whenever available for guidance in establishing a maintenance schedule.

NOTES:

2. EXTERIOR ENVELOPE

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2.1 AIR LEAKAGE AND NATURAL VENTILATION

- Inspect the building exterior and interior surfaces and caulk all cracks that allow outdoor air to penetrate the building skin.
- Caulk around all pipes, louvers, or other openings which penetrate the building skin.
- Repair broken or cracked windows. Replace with standard or tempered glass of proper thickness, according to building code requirements.
- Weatherstrip exterior doors and windows.
- Cover window air conditioners with insulation and plastic covers in the winter (when not used for heating).
- Install automatic closers on exterior doors.
- Seal elevator shafts top and bottom and see that the machine room penthouse door is weatherstripped and closed.
- Weatherstrip and close doors in basement and roof equipment rooms.

2.2 SOLAR SHADING

2.2.1

For mechanically cooled buildings, windows on the southern and western exposures should be fitted with some form of solar shading device to reduce the solar heat gain. Examples for consideration are:

- Overhangs
- Fins
- Solar Screens
- Awnings
- Interior Drapes
- Venetian Blinds

2.2.2 BENEFICIAL SOLAR HEAT GAIN

During the heating season, the following actions should be taken to use solar radiation to aid in reducing the building's energy requirement.

- Clean windows to permit maximum sunlight transmission.
- Operate drapes and blinds to permit sunlight (when available) to enter windows during the winter; move desks or work stations out of direct path of sunlight to avoid occupant discomfort.
- A percentage of direct solar radiation is stored in the structure and furnishings where it will help to offset the heat load at night. Permit the space temperature to rise at the end of the day and be available for heating at night or cloudy periods. Even on cloudy days diffuse radiation is considerable; allow it to be transmitted into the occupied areas.
- If windows are not fitted with blinds, drapes, or shutters, install them to control the rate of heat flow into and out of the building.
- If direct sunlight or excessive window brightness causes glare, add a light transluscent drape which cuts glare but permits solar heat to enter.
- Readjust blinds during the day, if overheating occurs.
- Trim all foliage shading the southern, eastern or western face of the building in winter. Reduce any evergreen foliage grossly blocking the winter sun, except where this foliage acts as a valuable windbreak.
- Where possible, remove shading devices and any other objects casting shadows on the building surfaces during winter.

2.2.3 RADIATION EFFECTS OF COLD SURFACES

- When the winter sun is not shining on the windows, draw drapes or close venetian blinds or shutters to reduce radiation of heat from the windows.
- Close windows tightly in the winter.

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3. HEATING, VENTILATION, AIR CONDITIONING (HVAC) SYSTEMS AND EQUIPMENT

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3.1 CONTROLS

3.1.1 CONTROL ADJUSTMENT

- Adjust controls at time of testing, adjusting and balancing of all heating and cooling systems.
- Check operation of entire heating/cooling control systems, including control valves and dampers. Correct all improper operations.
- Check control system for instrument calibration and set point, actuator travel and action, and proper sequence of operation.
- Check the calibration of all controllers and devices for proper settings and operation.
- Adjust controls where applicable to prevent simultaneous operation of heating and cooling systems to achieve desired temperature.
- Consider locked setting thermostats or installation of protective covers over thermostats to prevent building occupants from adjusting settings, where applicable.

3.1.2 TEMPERATURE CONTROLS

3.1.2.1 Setback Temperatures During Unoccupied Periods

- Shut off radiators or registers in vestibules and lobbies.
- Reduce the hours of occupancy to the greatest extent possible during periods of severely cold weather.
- Adjust automatic timers or add time clocks to automatically setback temperature for night and weekend operation.
- When buildings are used after hours for meetings, conferences, cleaning or scattered activities, reduce the number of spaces occupied and, to the extent possible, consolidate them in the same section of the building. Reduce the temperature and turn off humidifiers in all other parts of the building.
- When there is no danger of freezing, turn off radiators or registers in areas that do not have a separate thermostat. Open them when building is occupied.

3.1.2.2 Setback Temperatures During Occupied Hours

- Corridors and stairwells are unoccupied areas, used only be people who are physically active in moving from one heated space to another. Providing that the temperature does not fall below 55°F., turn off heat in these areas.
- Keep all doors between unheated corridors and heated spaces closed.
- Some areas of the building require no heating - spaces which are heated by adjacent areas or which receive solar heat through windows. If thermostats are unavailable in these areas, shut off radiators, registers, fan coil units, or any other terminal to the extent that adequate temperature can be maintained.

3.1.2.3 Supply Air Temperature Controls

- Raise the supply air (or chilled water) temperature for cooling to the highest point necessary to provide minimum required cooling.
- Lower the supply air (or hot water) temperature for heating to the lowest point necessary to provide minimum required heating.

3.1.3 HUMIDITY CONTROLS

- Turn off all humidifiers at night and during unoccupied times.
- Reduce the amount of infiltration and outdoor air ventilation.
- Reduce or eliminate any introduction of moisture for humidification in corridors, storerooms, equipment rooms, lounges, lobbies and kitchens.
- Use waste steam condensate for winter humidification where possible.
- Whenever condensate is collecting on the inside of window surfaces, shut off humidifier. Excess moisture will waste fuel and damage structure.
- When humidifier is maintained to eliminate static electricity, shut off humidifier when shocks are not a problem.
- In pan-type humidifiers adjust float or control to eliminate overflow.

3.1.4 VENTILATION CONTROLS

- Open windows in lieu of operating ventilating system for outdoor air cooling, when feasible. (Be sure to take into consideration accoustical, odor and dust conditions).
- Operate without fresh air ventilation when the building is unoccupied.
- Reduce air circulation in all but smoking permitted areas of the building.

3.1.5 PNEUMATIC CONTROL SYSTEMS

3.1.5.1 Compressor and Drier

- Check the pressure settings.
- Inspect outlet air filter system on controls air compressor for proper removal of oil, moisture and dirt.
- If compressor seems to run excessively, determine cause and correct.
- Inspect air pressure in supply tank and pressure regulator adjustment in supply line for proper limits.
- Check belt tension and alignment.
- Inspect air compressor intake filter pads and clean or replace as necessary.
- Lubricate electric motor bearings according to manufacturer's recommendations.
- Check the compressor's oil level.
- Periodically drain the moisture from storage tank.

3.1.6 OTHER CONTROLS

- Consider regulating the fresh air dampers with enthalpy control so that the building can be cooled with outdoor air when this saves energy.
- Consider adding a discharge control load and analyzer to provide temperatures to match the loads.
- Consider a timeclock operation of the system.
- Shut down unneeded equipment such as pumps, water coolers, dispensing equipment, business machines by using time clock(s).

- Consider unoccupied zone shutdown dampers with fan volume control.
- Consider zone reset of hot and cold decks of the multizone units.
- Consider velocity pressure reset of hot and cold decks of the dual duct units.

3.1.7 CONTROL SEQUENCING

3.1.7.1 Heating Season

- 68°F maximum occupied, 60°F maximum unoccupied.
- Preheat space to 63°F prior to occupancy and then 68°F in first hour of occupancy.
- Cut off heat one hour before the end of occupancy.
- Consider the usage of time clocks for the points brought out in Section 3.1.6.
- Cut off all fresh air supply during the preheat period.
- Designate specific areas to be used during normal unoccupied hours to minimize the operating systems.
- Reduce the occupied cycle for outside air quantity to 5 CFM per occupant or as required by code.
- Consider clock operation of general and toilet exhaust systems.
- Check the systems for minimum required volume.

3.1.7.2 Cooling System

- 78°F minimum when occupied and no cooling when unoccupied.
- Precool building 5°F below outside or 80°, whichever is higher, prior to occupancy and complete cooling during the first hour of occupancy.
- Flush building at night with cool outside air. Do this only for the periods required to cool down.
- Consider the usage of timeclocks for the points brought out in Section 3.1.6.
- Provide atmospheric cooling as long as possible.

NOTES:

3.2. COMPONENTS

3.2.1 FANS

- Check for excessive noise and vibration. Determine cause and correct as necessary.
- Keep fan blades clean.
- Inspect and lubricate bearings.
- Inspect drive belts. Adjust or replace as necessary to ensure proper operation.
- Inspect inlet and discharge screens on fans. They should be kept free of dirt and debris at all times.
- Inspect fans for normal operation.

3.2.2 PUMPS

- Check for packing wear which can cause excessive leakage. Repack to avoid excessive water wastage and shaft erosion.
- Inspect bearings and drive belts for wear and binding. Adjust, repair or replace as necessary.

3.2.3 DUCTING

- Inspect ductwork for air leakage. Seal all leaks by taping of caulking.
- Inspect ductwork insulation.
- Check for any obstructions such as loose hanging insulation (in lined ducts), loose turning vanes and accessories, and closed fire dampers. Adjust, repair, or replace as necessary.

3.2.4 PIPING

3.2.4.1 Hot and Chilled Water Piping

- Check for leakage at all joints.
- Check flow measurement instrumentation for accuracy. Adjust, repair or replace as necessary.

- Inspect insulation of hot and chilled water pipes. Repair or replace as necessary. Where vapor barrier cover of chilled water pipe insulation has been damaged by water, the entire cover should be removed and replaced with new undamaged insulation and vapor barrier jacket to provide moisture free integrity. Hot pipe insulation can be repaired in field, without total replacement, through use of appropriate patching materials. Where water or moisture damage has occurred, determine source of water leakage and correct.
- Inspect strainers. Clean when required.
- Inspect heating and cooling system heat exchangers for proper operation.

3.2.4.2 Steam Piping System

- Inspect insulation on all mains, risers, branches, economizers and condensate receiver tanks. Repair or replace as necessary.
- Inspect steam traps. Repair as necessary. Inspect all pressure reducing and regulating valves and related equipment. Adjust, repair or replace as necessary.
- Observe condensate tank vent piping. Where plumes of steam appear make inspection of all stream traps to ascertain which one(s) are malfunctioning and correct this condition.
- Check and calibrate accuracy of gauges and thermometers.
- Correct sluggish or uneven circulation of steam.
- Correct any excessive noise which may occur in the system to provide more efficient heating and to prevent fittings from being ruptured by water hammers.
- Check vacuum return system for leaks.

3.2.5 DAMPERS

- Inspect damper blades and linkages. Clean, oil and adjust.
- Check fresh air dampers to make sure that they close tightly and be sure to repair, replace or provide blade edge and end of blade gasketing.

- Check fresh air damper control and operator for tight closing and for correct volume of minimum fresh air supply as per code requirements.
- Check for smooth operation, and lubricate periodically.
- Inspect mixing dampers for proper operation. Adjust as necessary.
- Adjust all VAV (variable air volume) boxes so they operate properly.

3.2.6 VALVES

- Check the operation for full opening and tight closing, and for leakage.
- Lubricate all bearings.

3.2.7 MOTORS

- Check alignment of motor to equipment driven. Align and tighten as necessary.
- Check regularly for loose connections and bad contacts.
- Keep motors clean.
- Eliminate excessive vibration.
- Lubricate motor and drive bearings.
- Replace worn bearings.
- Tighten belts and pulleys to eliminate excessive losses.
- Check for overheating due to a functional problem or lack of adequate ventilation.
- Balance three-phase power sources to motors.
- Check for over-voltage conditions on motors.

3.2.8 MOTOR OPERATORS

- Check for proper operation-travel to produce function intended.

3.2.9 FILTERS

- Clean or replace filters periodically or as indicated by filter gauges. If there are no gauges, consider installing them.

- Check the timer settings and mechanism on the automatic filter.
- If the automatic filters are advanced according to pressure requirements, check this control for proper functioning.

3.2.10 STRAINERS

- Clean all strainers in piping systems to insure full flow of medium.

3.2.11 HEAT EXCHANGERS

- Clean transfer surfaces periodically, inside and outside.

3.2.12 CONDENSERS

3.2.12.1 Air Cooled Condensers

- Keep fan belt drive and motor properly aligned and lubricated.
- Inspect refrigeration piping connections to the condenser coil for tightness. Repair all leaks.
- Keep condenser coil face clean to permit proper air flow.
- Determine if hot air is being by-passed from the fan outlet to the coil inlet. If so, correct the problem.

3.2.12.2 Evaporate Condenser

- Inspect the piping joints and seal all leaks.
- Remove all dirt from the coil surfaces.
- Inspect air inlet screen, spray nozzles or water distribution holes, and pump screen. Clean as necessary.
- Use water treatment techniques if local water supply leaves surface deposits on the coil.
- Follow guidelines for fan and pump maintenance.

3.2.12.3 Water-Cooled Condenser

- Keep the condenser shell and tubes clean of foreign materials.

NOTES:

3.3 HVAC EQUIPMENT EFFICIENCY

3.3.1 BOILER AND BURNER EFFICIENCY

3.3.1.1 General

- Clean and scrape fire-sides to remove soot and scale.
- Clean water-sides, remove built-up scale.
- Scrape scale from steam drum.
- Clean air-sides, remove soot, and scrape scale in forced warm air and hot air furnaces.
- Maintain water level or pressure to radiators or coil on the highest level of the building.
- Insulate units which are in unheated spaces, on roofs, or in air-conditioned spaces. Repair insulation where it is needed.
- Check for and seal air leaks between sections of cast iron boilers to improve combustion efficiency.
- If the combustion efficiency is at the maximum but stack temperatures are still too high (over 450°F), install baffles or turbulators to improve heat transfer. Consult your boiler manufacturer.
- Seal all air leaks into combustion chamber, especially around doors, frames and inspection ports.
- Maintain the lowest possible steam pressure suitable for supplying radiation or coils.
- Vary the steam pressure in accordance with the space heating or process demands. Steam pressures can be reduced most of the year. Standby losses are reduced as pressures are reduced.
- Maintain the lowest possible hot water temperature which will meet space or domestic hot water needs.
- In the absence of indoor-outdoor modulating controls, raise or lower the operating temperature (for hot water systems) to conform to indoor-outdoor conditions. For example, operate a boiler at 120°F with outdoor temperature at 60°F, and raise the level to 160° when it is 20° outdoors.

- Clean filters regularly in gravity and forced warm air units to reduce the operating time of the furnace.
- Reduce firing rate and/or enlarge return air opening if hot air temperature of a gravity furnace is over 150°F at full load.
- Shut down hot air furnaces completely when building is not occupied and there is no danger of freezing.
- Set operating aquastats on steam and hot water boilers to 100°F during shut-down periods.
- Schedule boiler blowdown on an as-needed basis rather than on a fixed timetable. Smaller and more frequent blowdown quantities are preferable to larger quantities and less frequent blowdown.
- Use warm exhaust air from adjacent areas, or from the ceiling of the boiler rooms, to preheat combustion air.
- Use chemical fuel additives to reduce the flashpoint temperature of fuel oil, especially #4 and #6 oils. Proper chemical treatment will reduce spot deposit on #2 oil systems also.
- Interlock combustion air intake with burner operations; maintain prepurge and postpurge as required for some burners.
- Seal all air leaks into natural draft chimneys, especially where flue pipe enters the wall.
- Repair or rebuild oil burner combustion chambers to the correct size for providing optimum efficiency at 90 percent of the full load firing rate. Construct chambers with bricks of the refractory type. Incorrect matching of burner and combustion chamber and broken brickwork can result in losses from 10 to 20 percent.
- Provide an automatic draft damper control to reduce the heat loss through the breeching (smoke pipe) when the gas or oil burner is not in operation. Adjust draft-control with combustion testing equipment to match the firing rate.

- Adjust oil burner efficiencies to achieve proper stack temperature, CO_2 and excess air settings. Adjust setting to provide a maximum of 400° - 500° of stack temperature and a minimum of 10 percent CO_2 at full load conditions. Excess air through a boiler can waste 10 to 30 percent of the fuel. Accurate testing is essential for the correct burner adjustment to atain maximum efficiency. Use appropriate instruments and institute combustion testing as part of a planned general and maintenance program.
- Check stack temperature and keep a weekly log. An increase in stack temperature usually means that accumulations of soot or scale are reducing the rate of heat transfer.
- Consider air supply to all boilers. Air inlets to boiler rooms should be kept clear. Blowers or fans and their drivers should be cleaned and put in good operating order.
- Check with the feed-water treatment supplier or consultant to prevent scale formation. Carefully follow recommendations concerning amounts or methods of feed-water treatment and blowdown. Maintain the water softener if one is installed.
- Adjusting the firing rate of gas or oil burners at too high a rate will cause short cycling and excessive fuel consumption. Too low a rate will require constant operation and inadequate heat will be delivered to the spaces. If the boiler is oversized, adjust the firing rate to the building load, not the boiler.
- If there is more than one boiler, operate one only up to its maximum load before bringing other boilers on the line. It is inefficient to operate two or more boilers at very low capacity to carry partial loads.

3.3.1.2 Gas Fired

- Turn off gas pilots for furnaces, boilers, and space heaters during the non-heating months and during long unoccupied periods.

3.3.1.3 Coal Fired

- Have the coal fired boiler stokers, grates, and controls examined for efficient operation. See that ash does not contain excessive unburned coal.

3.3.1.4 Electric

- Inspect electrical contacts and working parts of relays and maintain in good working order.
- Check heater elements for cleanliness. Replace as necessary.
- Check controls for proper operation. Adjust as necessary.
- Periodically tighten all electrical/mechanical connections to prevent arcing and burning due to metal flow or loosening of terminal bolts or lugs.

3.3.1.5 Make-Up Air and Unit Heaters

- All heat exchanger surfaces should be kept clean. Check air-to-fuel ratio and adjust as necessary.
- Inspect burner couplings and linkages. Tighten and adjust as necessary.
- Inspect casing for air leaks and seal as necessary.
- Inspect insulation and repair or replace as necessary.
- Follow guidelines suggested for fan and motor maintenance.

3.3.2 CHILLERS

3.3.2.1 Water Chiller Evaporator

- Water passage must be kept clean.
- Closed loop water chemical control and testing programs should be monitored and corrected as necessary to prevent foreign deposits on the heat exchanger surfaces.

3.3.2.2 Absorption Equipment

- Clean strainer and seal tank.
- Lubricate flow valves.
- Follow manufacturer's instruction for proper maintenance.

3.3.2.3 Self-Contained Units

- Clean evaporator and condenser coils.
- Keep air intake louvers, filters and controls clean.
- Keep air flow from units unrestricted.
- Caulk openings between unit and window or wall frames.
- Check voltage for proper machine operation.
- Follow applicable guidelines suggested for compressor, air-cooled condenser and fans.

3.3.3 COOLING TOWERS

- Analyze water and maintain water quality at an acceptable level.
- Check overflow pipe clearance for proper operating water level.
- Check fan by listening for any unusual noise or vibration. Inspect condition of V-belt(s) and drive. Align fan and motor as necessary.
- Follow guidelines for fan maintenance.
- Keep the tower clean to minimize both air and water pressure drop.
- Clean inlet strainer.
- Determine if there is air bypass from tower outlet back to inlet.
- Inspect spray filled or distributed towers for proper nozzle performance. Clean nozzles as necessary.
- Inspect gravity distributed tower for even water depth in distribution basins.

3.3.4 AIR HANDLING EQUIPMENT

3.3.4.1

- Inspect air washers and evaporate cooling equipment for proper operation. Clean damper blades and linkages if so equipped. Inspect nozzles and clean as necessary. A fully automatic chemical water treating system should be provided which controls feeding of chemicals and blowdown of minerals to prevent development of scale formation and foulants on the heat transfer surfaces. Slug feeding of microbiocide(s) should be made periodically, as necessary, to control microorganism growth in the spray water.
- Check electronic air cleaners for proper operation and for excessive accumulations on the ionizing and grounding plate section. Replace filter media if necessary. Follow manufacturer's written instructions whenever adjustment or maintenance is required.

3.3.4.2 Intakes

- Keep all birdscreens clean.
- Check the intake dampers for tight closing. Provide gaskets or repair gaskets, including end of blade gasketing.

3.3.4.3 Exhaust Systems

- Check for minimum required volume.
- Operate only during occupied periods.
- Provide local control (kitchen hoods, industrial hoods, fume hoods).
- Check the interlock systems so make-up air is provided only when exhaust is operating.
- Balance the make-up air to equal or slightly exceed exhaust.
- Consider cutting off the supply air to restrooms and other contaminated rooms and provide means of introducing air from adjacent spaces via undercut doors, door grilles or transfer ducts.

NOTES:

3.4 DISTRIBUTION SYSTEMS

3.4.1 Hot Water or Steam

- Clean the air side of all direct radiators, fin tube convectors and coils to enhance heat transfer.
- Keep radiators free from blockage. A one foot clearance in front of convectors, radiators, or registers is desirable. Heating systems, particularly hot water or electric baseboard radiators and low level warm air supply registers, work more efficiently if they are not blocked by furniture. Keep all books or other impediments from blocking heat or air delivery from the top of horizontal shelves or cabinets which enclose radiators, fan coils, unit ventilators or induction units.
- If radiator is set directly in front of a window where the glass extends below the top of the radiator, or in front of an uninsulated wall, insert a one inch thick fiberglass board panel, with reflective coating on the room side, directly between the radiator and the exterior wall to reduce radiation losses to the outdoors.
- Vent all hot water radiators and convectors to assure that water will completely fill the interior passages.
- Check radiator steam traps to assure that they are pushing only condensate, not steam.
- Make sure that all fans, (frequently inoperative in unit heaters), fan coil units, and unit ventilators are running normally to increase the heat transfer rate from heating coils.
- Use electric or infrared units as spot heaters for remote areas (a reception desk in a large lobby, for example) rather than operating an inefficient central system for a small area in the building.
- In the public spaces of all buildings such as lobbies, corridors, stairwells, vestibules and lounges, conserve energy by turning off unitary terminal units and removing the handles from control valves. If balancing cocks are included, turn them to the off position. In each stairwell of multi-level buildings, shut off all but the unit located at the bottom. Turn off heat in vestibules and foyers.

- Overhead unit heaters should direct heat to floors. Add directional louvers to focus heat to floor or areas requiring heat. Where possible, draw return air from floor.

3.4.1. HOT WATER OR STEAM

Steam Condensate Vent

- Inspect the condensate tank vent. A plume of steam indicates leaking traps and waste of steam and condensate.
- Study the plant to see if some condensate going to sewer can be safely returned to the boiler.

3.4.2 AIR SYSTEMS

- Clean and remove obstructions from all room air outlets and inlets (diffusers, registers and grilles). They should be kept clean and free of all dirt and foreign materials.

3.4.2.1 Terminal Reheat

- Check and raise if required, the supply air system temperature so only approximately 10 percent reheat units are operating.
- Consider interlocks between the cooling and heating operation to prevent simultaneous cooling and heating.

3.4.2.2 Dual Duct Systems

- Consider controls to close off cold duct when no cooling is required, and rescheduling warm duct temperature.
- Consider controls to close off hot duct when no heating is required, and rescheduling cold duct temperature.
- Check for leaking dampers in mixing boxes.
- Inspect and calibrate pressure controls to obtain minimum static pressure during low demand.

3.4.2.3 Multi-Zone Units

3.4.2.4 Check for Leaking Zone Dampers

Induction Systems

- Check for scheduling of hot water and chilled water in accordance to load requirements.

- Check and clean the lint screens.
- Clean all coils
- During unoccupied periods shut down the primary air system and operate units as convectors.

3.4.2.5 Variable Volume Systems

- Check fan volume control operation and adjust to prevent excessive system pressure.
- Check the supply air temperature schedule so most extreme load box damper is fully open.
- Check the operation of all VAV boxes to prevent overheating or overcooling.
- Check for code requirements of the outside air.

3.4.2.6 Fan-Coil Systems

- Check the units for clean filters, and coils.
- Check the outside air dampers or openings and close same if infiltration equals or exceeds fresh air requirements.
- If the unit is outside conditioned space, insulate the unit and its connecting ductwork.

3.4.2.7 Window and Thru-Wall Units

- Clean condenser and evaporator coils and intake louvers.
- Caulk openings between unit and window or wall frames.
- Remove units or cover them with weather-tight hoods during the winter.
- Consider thermostatic control or timers to shut units off automatically.
- Turn off cooling unit and fan when leaving the area.
- Outdoor air inlets to units with resistance heaters are usually fixed, bringing in outdoor air whenever the units are operating. Close these inlets when unit is not in operation or block off if infiltration meets outdoor air requirements.

NOTES:

3.5 AIR AND WATER BALANCING

- Balance air and liquid flows to produce required quantities and distribution with minimum energy use. Consideration should be given to contracting this type of service to a recognized testing and balancing firm with proper instrumentation and personnel. Care should be exercised in the balancing to insure that the needed quantities of media (air and liquid) and not just the original design quantities are used in the balancing. At any time modifications are made to the air or water systems, rebalancing of affected system(s) should be immediately accomplished.

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4.1 WATER SUPPLY

4.1.1 CIRCULATING PUMPS

- Reduce the water flow to minimum requirement.
- Regularly adjust the pump packing glands to limit water waste.
- Check the pump motor power input. If it is less than 60 percent of nameplate, consider a change in the pump or impeller for a more efficient operation.
- Lubricate as per manufacturer's recommendations.
- Check the setting of aquastat on the domestic recirculation systems (approximately 5° - 10°F lower than the water supply temperature depending on the length of piping system and insulation condition.)
- Shut off the pump during unoccupied periods.
- Check pumps for "free-run" and excessive packing gland pressure.

4.1.2 PIPING SYSTEMS

- Insulate or repair insulation on the hot water and recirculating hot water piping.
- Check for and correct water leaks.
- Check filters and strainers periodically. Clean and/or replace.

4.2 SERVICE WATER HEATING

- A separate means of turning off the energy source to the service water heating units should be provided so that the units can be deactivated when not in use.
- All insulation applied to a hot water system should be kept in good condition.
- The burner system of fossil-fuel water heaters should be kept clean and in good operating condition.

- All electric heating equipment should be checked for corrosion of the elements and loose connections, and repaired as required.
- Adjust for a 110° water supply for all except special requirements (dishwasher supply units, etc.). If necessary to elevate temperature reduce the temperature after the elevated temperature requirement ceases.
- Check the operation of the temperature controller so overheating does not occur.
- Check for defective relief valves.
- Periodically drain; remove the sediment.
- Check the back flow preventers for excessive relief valve operation. If due to water hammer, consider adding a shock absorber.
- Separate Service Hot Water Supply System.

  Where boilers are operated at high capacity during the heating season and at reduced capacity during the cooling season to supply service hot water, a separate smaller hot water supply system should be installed to operate at optimum efficiency, to avoid operation of large boilers at low efficiency during times of reduced load. Care should be taken to insure that adequate supplies of fuel (gas, oil, electricity) are available with necessary flue gas capabilities to make the above conversion practical.
- Oil Fired Water Heaters

  Check for adequate ventilation (combustion air).

  Check the burner adjustment for efficient operation.

  Check the burner fuel oil filter, and replace periodically according to the manufacturer's instructions.
- Boiler tankless heaters should be checked to make sure coils are covered with water.
- Shut down heating equipment during unoccupied period or when hot water is not required.

4.3 SEWAGE SYSTEM EQUIPMENT AND CONTROLS

- Check and clean strainers periodically.
- Lubricate as per manufacturer's recommendations.
- Check for loose couplings.
- Check for impeller clearance to suction plate.
- Check float operation.

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5. ELECTRICAL SYSTEMS

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5.1 GENERAL

- Check for excessive voltage drop on any circuit.
- Tighten and clean all electrical connections from the circuit breakers back through the transformers to the main switch gear. Note: This should be done at least once a year by a qualified electrician when the building power is shut off. This is not only a precaution, but can also reduce electrical losses.
- Keep all switch gear free of dust.
- Check power factor and make adjustments to correct equipment, if necessary.

5.2 REDUCE TRANSFORMER LOSSES

- Disconnect transformers supplying unused offices or other areas.
- Disconnect refrigeration chiller transformers during the cooling season, if not required.
- Disconnect heating equipment transformers during the cooling season.
- Where there is a bank of two or more transformers, operate transformers at the most efficient loading point.
- Reduce copper losses in the wiring which increase with ambient temperature by ventilating transformer vaults to reduce the ambient temperature.
- Shade outdoor transformer banks from solar radiation.
- Disconnect dry type transformers serving convenience outlets when there is no load at night and during weekends and holidays.

5.3 INCREASE MOTOR EFFICIENCY

- Tighten belts and pulleys at regular intervals to reduce losses due to slippage.
- Lubricate motor and drives regularly to reduce friction.
- Replace worn bearings.

- Check alignment between motor and driven equipment to reduce wear and excessive torques.
- Keep motors clean to facilitate cooling.
- When replacing worn or defective motors, replace with motor that is sized as close to load as possible, and use the highest efficiency motor available.
- Where it is impracticable to replace motors which have low load and power factors, use capacitors at motor terminals to correct the power factor to 90 percent.

5.4 LOAD MANAGEMENT

- Consider electrical load management for power demand monitoring and limiting.
- Consider reduction or switching of operating hours to avoid period of peak electrical demand. Electricity can be used more efficiently if some use can be diverted to off-peak periods when voltage remains high.
- Schedule discretionary loads to off-peak operation thus reducing peak demand.

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6. LIGHTING

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- Lamps depreciate in light output during life and fixtures and lamps collect dirt, both of which can reduce light delivered to tasks up to 70 percent. This effect is usually imperceptible, occurring slowly with time. Much lighting energy can be saved through maintenance programs that recognize the light loss factors and minimize them with periodic servicing. Lighting systems should have regular cleaning of fixtures and lamps. Fixtures in dirty areas should be enclosed to reduce the effects of dirt collection. Replacing lamps in groups before they burn out maintains higher average light output per fixture.

  In existing systems, good maintenance can:

- Provide more light for productivity with no increase in energy use.
- Allow part of a lighting system to be turned off, yet maintain the necessary light.
- Allow lower wattage lamps to be used to provide the necessary illumination.

6.1 INCREASING LIGHTING SYSTEM EFFECTIVENESS

- Keep walls, ceiling and floors clean.
- When repainting, use light colored paint on ceilings, walls and floors but avoid reflections from glass finishes.
- When recarpeting or retiling, put in lighter colored carpets or tiles.
- When refurnishing, select lighter color furnishings.
- Decrease partition heights where possible. (Check for compliance with building and fire codes, as well as occupational standards for noise).
- To reduce glare, rearrange work stations so that side wall daylight crosses perpendicular to the lines of vision.
- In the winter, open blinds and drapes even if space mildly overheats.
- In buildings without air conditioning systems, open blinds and drapes in summer even if space mildly overheats.

6.2 MINIMIZING USE OF LIGHTING

- Mark all ganged switches with identification of the lights controlled. Color code switches and institute a program of use. (e.g., Blue 7 a.m. - 6 p.m., Red 9 a.m. - 12/1 p.m. -4:30 p.m., etc.).
- Instruct occupants and maintenance personnel to switch off all lights which are not required for portions of the day, including light for:

  storage rooms;
  vending machines (use vending machine illumination);
  mechanical equipment rooms;
  auditoriums, conference rooms and cafeteria (when not used);
  meeting rooms (when not used);
  bulletin boards;
  office directories;
  unassigned office areas;
  any areas where natural light is available; and
  loading docks.
- Where possible use flourescent lights instead of incondescent lights.
- Turn off display case internal lighting, when premises are unoccupied.
- Turn off flood lighting which is strictly decorative.
- Maintain hazard and egress lighting at all times as required by building and fire codes.
- Substitute small table or floor-mounted lamps in lounge areas or waiting rooms and turn off modular ceiling fixtures.

6.3 MAKING BETTER USE OF DAYLIGHT

- Clean windows and skylights.
- Where practical, schedule periods of occupancy, cleaning and meetings to make maximum use of daylight.
- Locate tasks that need the best illumination closest to the windows, with the task-viewing angle parallel to the windows.

6.4 REDUCING OUTDOOR AND SECURITY LIGHTING

- Direct security lighting where it is most required, such as at windows and entrances and reduce it where the security problems are minimal.
- Reduce outside lighting in parking lots and at building signs and entrances to the minimum.
- Turn off all lights other than those needed for security, when the building is unoccupied.
- Consider the use of photo-electric and/or time clocks for controlling outside and display lighting. Depending upon the hours of use one or the other may save more energy depending upon the program.

6.5 REDUCING CUSTODIAL LIGHTING

- For cleaning which must be done at night, turn on lights only in that portion of the building which is being cleaned at that time.
- Consider providing as much janitorial service as possible during normal working hours.
- Perform janitorial services earlier so that lights may be turned off earlier, where natural light is available.
- Attempt to schedule all cleaning in one area at a time so that a portion of the building with minimum janitorial lighting is completed by the entire staff. The staff should turn off the lights and then proceed to other areas of the building.

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7. OTHER ENERGY USES

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7.1 ELEVATORS AND ESCALATORS

- Reduce the number of elevators in service during hours of least use.
- Turn off the motor-generator set located in the elevator machine room when not in use such as nights, weekends, and holidays.
- Reduce speed of escalators and elevators.
- Where security arrangements permit, encourage employees to walk up and down stairs.
- Consider turning off all down escalators during periods of light traffic.

7.2 COOKING

- Encourage chefs to preheat ovens no earlier than necessary and to forego preheating completely except for baked goods.

7.3 REFRIGERATION

7.3.1 REFRIGERATION CIRCUIT AND CONTROL

- Inspect moisture-liquid indicator.
- Use a leak detector to check for refrigerant and oil leaks around shaft seal, sight glasses, valve bonnets, flanges, flare connections, relief valve on the condenser assembly, and at pipe joints to equipment, valves and instrumentation.
- Inspect equipment for any visual changes such as oil spots on connections or on the floor under equipment.
- Inspect the liquid line leaving the strainer. Clean as required.
- Listen to the noise made by the system. If unusual sounds are noted, determine the cause and correct.

- Establish what normal operating pressures and temperature for the system should be. Check all gauges frequently to ensure that design conditions are being met.
- Where applicable, lubricate motor bearings and all moving parts according to manufacturer's recommendations.
- Inspect insulation on suction and liquid lines. Repair as necessary.

7.3.2 REGRIGERATION COMPRESSOR

- Look for unusual compressor operation such as continuous running or frequent starting and stopping. Determine the cause and, if necessary, correct.
- Observe the noise made by the compressor. If unusual sounds are noted, determine the cause and correct.
- Check all compressor joints for leakage. Seal as necessary.
- Inspect the purge for air and water leaks. Seal as necessary.
- Inspect instrumentation frequently to ensure that operating oil pressure and temperature agree with manufacturer's specifications.

7.4 APPLIANCE USE

- Turn off coffee pots and food warmers when not in use.
- Turn off refrigerated drinking fountains at the end of normal business hours.
- Where food spoilage is not a problem turn off vending machines at the end of the week. Use time clock to turn on the vending machine in time for the soft drinks to reach 45°F by Monday morning at employee arrival time.
- Turn off portable electric heaters, portable fans, typewriters, calculators, and reproduction machines when not in use.

7.5 OTHER EQUIPMENT USE

- Encourage employees to go to the cafeteria or canteen for coffee breaks rather than operating coffee percolators in offices.
- Prohibit use of portable electric heaters; if drafts or cold radiation from windows are causing employees discomfort, eliminate drafts by weather stripping windows.
- Where practical, substitute manual labor for electrical power, such as using manual labor to remove snow and ice rather than electric resistance snow melting systems.

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